# 4. REVISED 1-129 SOURCE TERM

Several lines of evidence suggest that the injection well 1-129 source term assumed in the 1997 RI/BRA groundwater modeling was too high. First, the total 1-129 estimated to be present within the groundwater plume is far less than the 1.39 Ci total 1-129 that the RI/BRA assumed to have been discharged to the injection well (Beasley, Dixon, and Mann 1998). Second, it appears that the period for which 1-129 discharge data are available (1976 to present) includes a time period during 1978–79 when 1-129 releases to service waste were higher than normal. The post-1976 1-129 data were averaged during the RI/BRA to obtain an estimate of the monthly 1-129 discharge to the injection well. Because the 1-129 pulse that occurred in 1978–79 was included in the calculations, a higher monthly average was obtained than if this period had been excluded. And finally, process knowledge indicates that before startup of the Waste Calcining Facility (WCF) in 1963, most of the 1-129 released during spent fuel processing would have accumulated in the high-level liquid waste stored at the tank farm, rather than be discharged to the injection well. Therefore, another evaluation of 1-129 discharges to the injection well is warranted. The approach to this problem, along with detailed calculations and the results of a revised injection well 1-129 source assessment, are presented in Engineering Design File (EDF) -3943 (Appendix D to this document). A brief summary of the revised 1-129 source term estimate is presented below.

As a fission product, the 1-129 present at INTEC is attributable to activities associated with the management of spent nuclear fuel. Essentially all of the 1-129 was present within the spent fuel brought to INTEC for processing; virtually no 1-129 was produced at INTEC. Therefore, it is possible to calculate the approximate total 1-129 inventory that has been present at INTEC based on the total quantity of spent fuel reprocessed. Cordes (1978) performed such an analysis using the "fissions processed" approach, along with the 1-129 fission yield. Using this approach, Cordes estimated that a total of approximately 5 Ci of 1-129 was present in the fuel processed from 1953 to 1977. Virtually all of this total would have been released to the first-cycle raffinate during spent fuel dissolution. Following its liberation from the spent fuel, the 1-129 would have ended up at one of the following four destinations: (1) temporary storage in tank farm liquid waste, (2) atmospheric discharge from the main stack, (3) groundwater discharge of process equipment waste to the injection well, and (4) storage in solid calcine material in WCF bins. McManus et al. (1982) performed a detailed study of 1-129 fate at INTEC and determined that the vast majority of the 1-129 was discharged to the atmosphere through the main stack. A much lesser quantity of 1-129 went to the injection well, and only a negligible quantity would have ended up in the solid waste (calcine).

McManus et al. (1982) also investigated the relationship between the plant processes and 1-129 activity in service waste. Among other findings, their study demonstrated that 1-129 releases from INTEC were related primarily to (1) WCF operation and (2) high-level waste evaporator (HLWE) operation. When the WCF was operating, overall 1-129 discharges to both the atmosphere (via the main stack) and to service waste were higher. When the HLWE was operating, 1-129 activities in service waste increased by approximately a factor of 10, as compared to periods when the HLWE was not operating.

Historical information on WCF and HLWE operational periods and the correlation between operational status of these two facilities and 1-129 activities in service waste are included in EDF-3943 (Appendix D of this document). Using this information, the total 1-129 activity discharged to the former injection well during its lifetime was recalculated. These calculations are based on historical records of the operational status of the WCF (or New Waste Calcining Facility) and the HLWE, coupled with the observed 1-129 activities in the service waste during periods when the WCF and/or HLWE were operating (or not). These calculations indicate that a maximum of 0.86 Ci 1-129 was discharged to groundwater through the former injection well during its lifetime. This value is approximately 62% of the previous estimate of 1.39 Ci 1-129 used in the RI/BRA modeling. While the new estimate still appears too large based on the amount of 1-129 present in the aquifer, it nevertheless appears to be more realistic than the

RI/BRA total 1-129 value. Refer to EDF-3943 for details on the 1-129 calculations and assumptions, along with additional supporting information regarding the factors affecting the disposition of I-129 at INTEC during spent fuel reprocessing.

# 5. COMPARISON OF SIMULATED AND OBSERVED AQUIFER CONDITIONS NEAR THE INTEC

Modeling the SWA for the Waste Area Group 3 Operable Unit 3-13 RI/BRA (DOE-ID 1997) predicted a risk beyond the year 2095 to groundwater users. High concentrations of 1-129 were predicted to remain in the low-hydraulic-conductivity HI sedimentary interbed. However, the OU 3-13 RI/BRA modeling was performed using only a limited amount of empirical data for parameterizing the HI interbed; no empirical data were available for verifying the presence or absence of contaminants in the interbed.

The OU 3-13 RI/BRA aquifer model was updated during OU 3-13, Group 5 remedial actions (DOE-ID 2002b). The aquifer model update included rediscretization and re-parameterization to more accurately simulate the HI interbed and deep aquifer. Field and laboratory testing performed for this report provided vertical profiling of I-129, Sr-90, Tc-99, tritium concentrations, and geotechnical data across the HI interbed at four borings downgradient of the INTEC. These data were used to adjust the current model's interbed parameterization and contaminant source terms to be consistent with the latest observations. Furthermore, the 1-129 source term was revised by analysis of historical INTEC processes. A complete description of the current WAG 3 aquifer numerical model is provided in Appendix B. Only the model's purpose, description, and simulation results are summarized in this section.

## 5.1 Model Purpose

The RGs of OU 3-13, Group 5 are to monitor groundwater concentrations and perform treatability studies if groundwater concentrations exceed the specified action level. The numerical model will be used to assess the effectiveness of different remedial scenarios, assess hture concentrations from current observations, or adjust the action level.

Updating the Group 5 aquifer model will coincide with updating the Group 4 aquifer model and developing the OU 3-14 aquifer model. The contaminated perched water addressed by the Group 4 RGs does not pose a risk to human health because it is not available for consumption. However, the perched water does pose a risk as a contaminant transport pathway to the SWA. The Group 4 aquifer model along with an updated vadose model will be used to assess the effectiveness restricting various surface water recharge sources to minimize transport of contaminated perched water to the aquifer.

The purpose of the OU 3-14 aquifer model will be to calculate hture risks from COCs identified in the OU 3-14 RI/FS and evaluation of proposed remedial actions. The following summarizes the primary anticipated uses of the OU 3-14 simulation results: (1) Baseline tank farm risk evaluation from the groundwater pathway. Aquifer concentrations will be predicted and used for the risk assessment. (2) Baseline cumulative risk evaluation. The cumulative risk from all the INTEC sources including OU 3-14 sources, OU 3-13 sources excluding tank farm source, and INEEL CERCLA Disposal Facility sources. (3) Evaluation of proposed remedial actions. During the feasibility study phase of the OU 3-14 RI/FS, remedial action alternatives will be recommended and the model will be used to evaluate the effectiveness of these alternatives.

## 5.2 Model Description

The WAG 3 aquifer modeling was performed using the TETRAD multipurpose simulator software (Vinsome and Shook 1993). The aquifer model domain extends from approximately 2.5 km north of the INTEC facility to the southern INEEL boundary in the north-south direction and approximately 6.5 km east of the INTEC facility to approximately 1 km west of the Radioactive Waste Management Complex

(RWMC) facility in the east-west direction. The model was discretized (subdivided) into 400 x 400 grid blocks in the horizontal and used variable vertical discretization that followed the HI interbed.

The aquifer model used four distinct stratigraphic types. These include the E through H basalts, the upper I basalt, the HI interbed, and the lower I basalt. The upper I basalt was defined as the top 25 m of the aquifer where the I basalt flow is at or above the water table. This part of the I basalt flow was separated from the majority of the I basalt flow because it is at the water table and wells are completed in this area of the I basalt flow, providing a pump-test-based permeability field.

The Big Lost River flows across the aquifer model domain, and the long-term average infiltration from the Big Lost River was applied directly in the aquifer model outside the area of the OU 3-13 RI/BRA vadose zone model footprint. Infiltration within the footprint was accounted for indirectly through the water and contaminant flux boundary condition from the OU 3-13 RI/BRA vadose zone model. In addition to the Big Lost River, the pumping from the water supply wells (CPP-02, CPP-04, CFA-1, and CFA-2) and reinjection into the former injection well (CPP-03) were included in the simulations. The boundary conditions included the following: specified flux at the surface (including the water sources discussed above), no flux at the bottom, and specified heads on the sides.

## 5.3 Current Model Predictive Simulations

The contaminants with substantial aquifer plumes migrating from the INTEC were simulated with the current model. The simulated contaminants included the following: I-129, tritium, Tc-99, and Sr-90. Table 5-1 lists each contaminant, the half-life, the partition coefficients ($K_d$), the $10^{-6}$ risk concentration, and the federal drinking water standard (MCL). The partition coefficients of the contaminants that react with the subsurface (Sr-90 and Tc-99) were calibrated to better match the observed plumes. The Tc-99 and Sr-90 partition coefficient calibration is discussed in Sections 5.3.3 and 5.3.4, respectively. The simulations used the Waste Area Group 3 Operable Unit 3-13 RI/BRA vadose zone simulations as the upper water and contaminant boundary condition and contain all the uncertainties of the Operable Unit 3-13 RI/BRA vadose zone model. The tritium flux rate was adjusted to match vertical concentrations measured downgradient in the vertical profile boreholes. This upper boundary condition represents water flow from the vadose zone and contaminant flux from soil contamination, tank farm releases, and the CPP-3 injection well during the period it failed and discharged to the vadose zone.

The tritium flux rate needed to be adjusted because the current tritium concentrations in the aquifer near the INTEC are most likely the result of continuing contaminant sources from the INTEC vadose zone. Simulations of the INTEC large-scale tracer test performed in 2001 using the Operable Unit 3-13 RI/BRA vadose zone model"indicated that the effective interbeds conceptual model is inadequate for representing the actual system. If monitoring locations were located below the model's first sedimentary interbed, then the simulated tracer concentrations produced by the OU 3-13 model generally lagged behind field measurements. This was because the simulated interbeds may be laterally more extensive and have a lower permeability than the actual interbeds. In general, these results indicate that the actual tracer was able to move much faster in the vertical direction than the simulated tracer.

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a. EDF-3213, 2003, "Idaho Nuclear Technology and Engineering Center Large-Scale Tracer Test Simulation (Draft)," Idaho Completion Project, December 2003.

Table 5-1. Predictive simulation contaminant parameters.

| Contaminant | Half-life (years) | Sediment $K_d$ (ml/g) | Basalt $K_d$ (ml/g) | Federal Drinking Water Standard" (pCi/L) |
|---|---|---|---|---|
| 1-129 | 1.57e+7 | 0 | 0. | 1 |
| Tritium (H-3) | 12.3 | 0 | 0. | 20,000 |
| Sr-90 | 29.1 | 6 | 0.1 | 8 |
| Tc-99 | 2.11e+5 | 0.075 | 0.0013 | 900 |

a. Based on the National Interim Primary Drinking Water Regulations (EPA 1976).

Furthermore, geochemical analysis of perched water and disposal pond water (DOE-ID 2003b) indicated that the disposal pond water did not move as far laterally as the OU 3-13 RI/BRA model predicted. These discrepancies between the observed and the OU 3-13 RI/BRA vadose model simulated conditions indicate the RI/BRA boundary condition is an uncertain model input, which may need to be adjusted in the aquifer model update.

The injection well 1-129 source was thought to be conservatively overestimated in the OU 3-13 RI/BRA modeling and was reevaluated in the current modeling.

The current model's predictive simulations are discussed in Sections 5.3.1 through 5.3.4.

### 5.3.1 Iodine-129

The OU 3-13 RI/BRA 1-129 source consisted of 1.52 Ci and was divided between 91.6% injection well, 5% percolation ponds, and 3% other sources. The 1-129 discharge data to the CPP-3 injection well were only reported from 1976 through 1985 and the RI/BRA model's injection well 1-129 source was extrapolated before 1976. The RI/BRA I-129 source overpredicted current concentrations observed in the aquifer.

The injection well source was reduced from 1.39 Ci to 0.86 Ci, based on analysis of the historical INTEC processes and the need to better match current aquifer concentrations. A full explanation of the revised 1-129 source term is presented in Section 4 and Appendix D.

Perched water concentrations that may be the result of the injection well collapse and subsequent discharge to the vadose zone also may suggest that the early RI/BRA 1-129 source may have been overestimated. The average I-129 concentration using the RI/BRA source was approximately 30 pCi/L during the reported period. This value was calculated from the average disposal rate of $1.2 \times 10^8$ pCi/day in 4,000 $m^3$/day of injection water (DOE-ID 1997). The deep-perched water near the injection well should be near this concentration, if significant water is not moving through the perched water and the RI/BRA I-129 source is accurate. However, sampling of the nearest deep-perched water sampling location (USGS-50) to the CPP-3 injection well detected 1-129 at 0.65 pCi/L (DOE-ID 2003b), suggesting that the 1-129 source strength might have been significantly overestimated or there is a significant flux of clean water moving through the perched water.

The 1-129 concentrations simulated by current model with the new source term exceeded the MCL through the year 2060. The simulated 2001 peak 1-129 concentration was 3.0 pCi/L and was located approximately 400 m west of the Central Facilities Area (CFA). The peak measured 1-129 concentration during 2001 sampling was 1.06 pCi/L in Well LF3-08, which is located approximately 1,000 m northwest of the CFA. The simulated 2095 peak 1-129 concentration was 0.5 pCi/L and was located south of the INTEC near the southern INEEL boundary. The much-higher-simulated-than-observed I-129 concentrations in 2001 suggest the revised source term discussed in Section 4 may still be overestimating the 1-129 source. Figures 5-1 through 5-4 illustrate simulated 1-129 peak aquifer concentrations, horizontal concentrations in 2001, vertical concentrations in 2003, and a comparison of simulated and observed concentrations in the vertical profile boreholes in 2003, respectively. The observed I-129 concentrations from 2001 sampling are illustrated in Figure 5-5. Simulated horizontal concentrations are presented for 2001, because the last round of complete aquifer sampling was performed in 2001 and these observations provided the best data set for model comparison.

The CFA-1 and CFA-2 production wells historically have produced approximately 250,000 gal/day and the wells were included in the aquifer simulations. The total 1-129 produced from these two water-supply wells for the period 1954 through 2003 was only 0.01 Ci. This value is only a small fraction of the total 1-129 injection well inventory, because the 1-129 plume is very dilute at the production well locations. The model indicates the wells do not capture a significant portion of the 1-129 plume.

It appears that the current 1-129 contamination in the aquifer near INTEC primarily is derived from 1-129 discharged in the former percolation ponds and 1-129 that entered the vadose zone during the injection well collapse that is slowly migrating to the aquifer. The 1-129 resulting from the injection well should have moved far south of the INTEC facility by this time, because of the fast aquifer velocity (approximately 2 m/day) and the fact that regular injection well operation ceased in 1984. However, very low permeability and localized basalt formations near INTEC could be slowly releasing I-129 under the natural gradient. The groundwater mound resulting from the injection well operation most likely produced an artificial gradient, which may have moved contaminants in the lower permeability basalt relatively quickly compared to their release under the natural gradient. Approximately 7% of the total 1-129 source was discharged to the vadose zone via the percolation ponds and the injection well during the well collapse period. The 1-129 concentrations should decrease in the hture as the vadose zone sources are depleted. The conclusions regarding current 1-129 contamination in the aquifer near the INTEC are based on the conceptual and numerical modeling assumptions presented in this report.

Simulated I-129 concentrations were higher than those observed. Groundwater monitoring results for 2003 show 1-129 concentrations below the MCL at all locations. The difference between simulated and measured 1-129 concentrations may be due to overestimation of the 1-129 source term or some unknown attenuation mechanism such as adsorption, which is not considered in the current conceptual and numerical model.

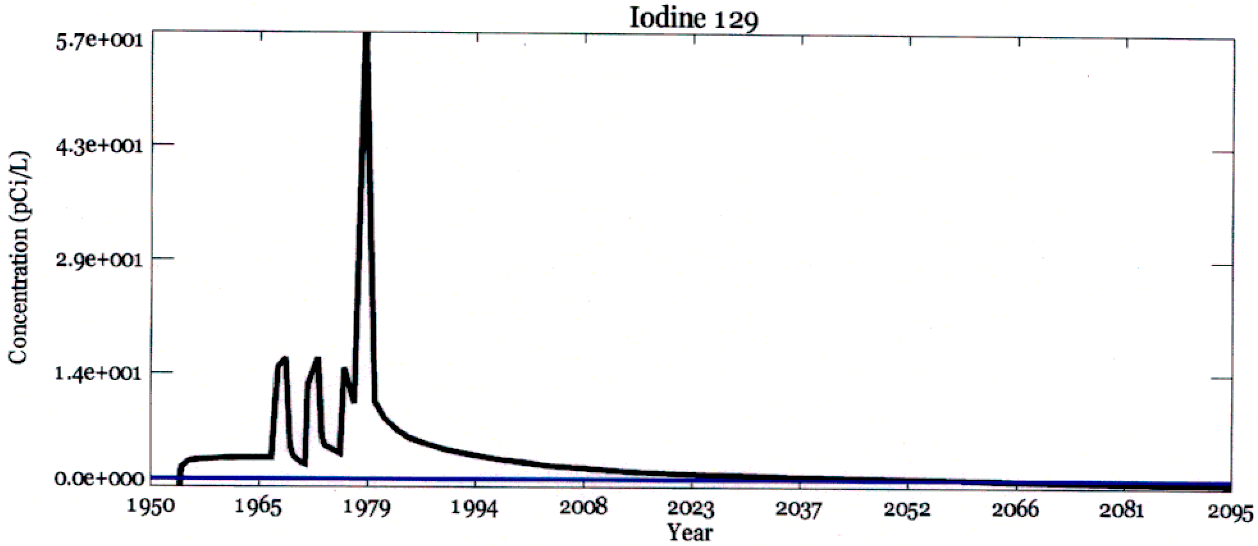


Figure 5-1. Simulated I-129 peak aquifer concentrations (blue line is the MCL).

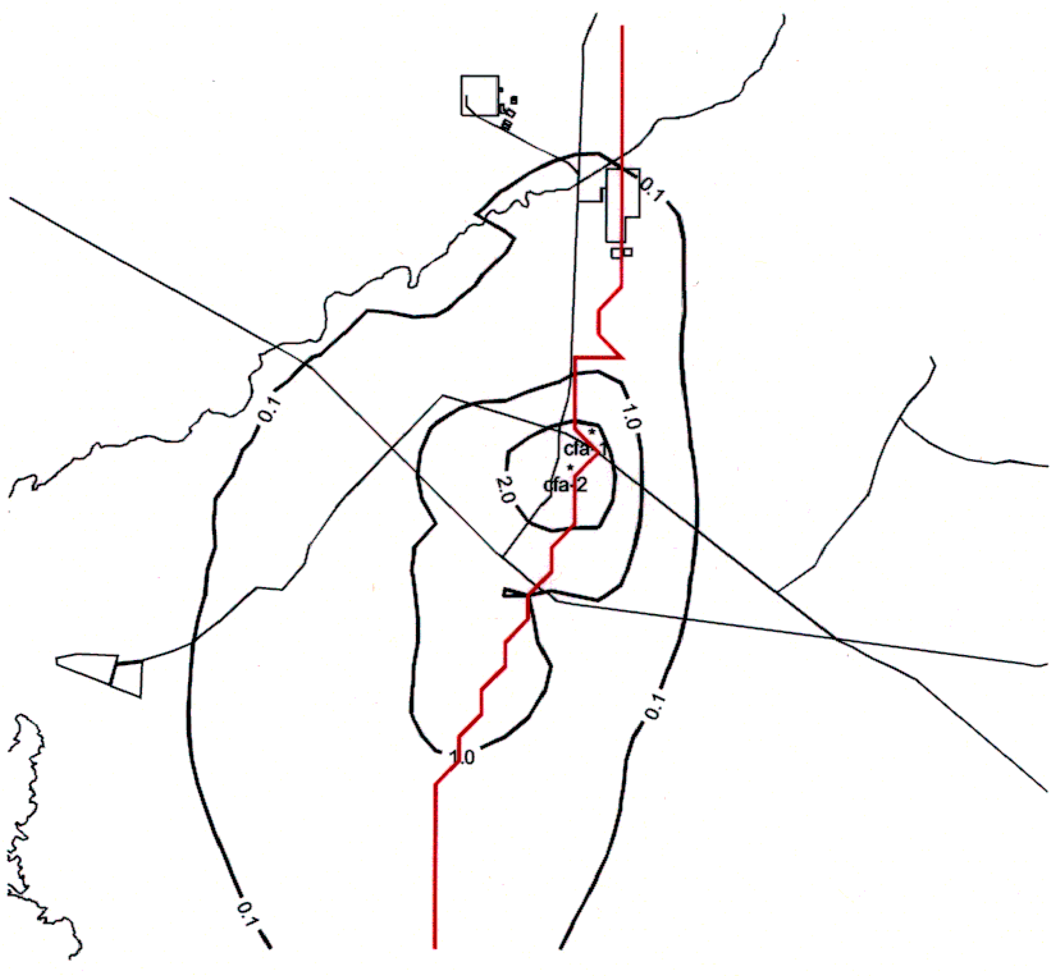


Figure 5-2. Simulated I-129 (pCi/L) concentrations at the water table in 2001 (the thick red line is a fence diagram cross-section for Figure 5-3).

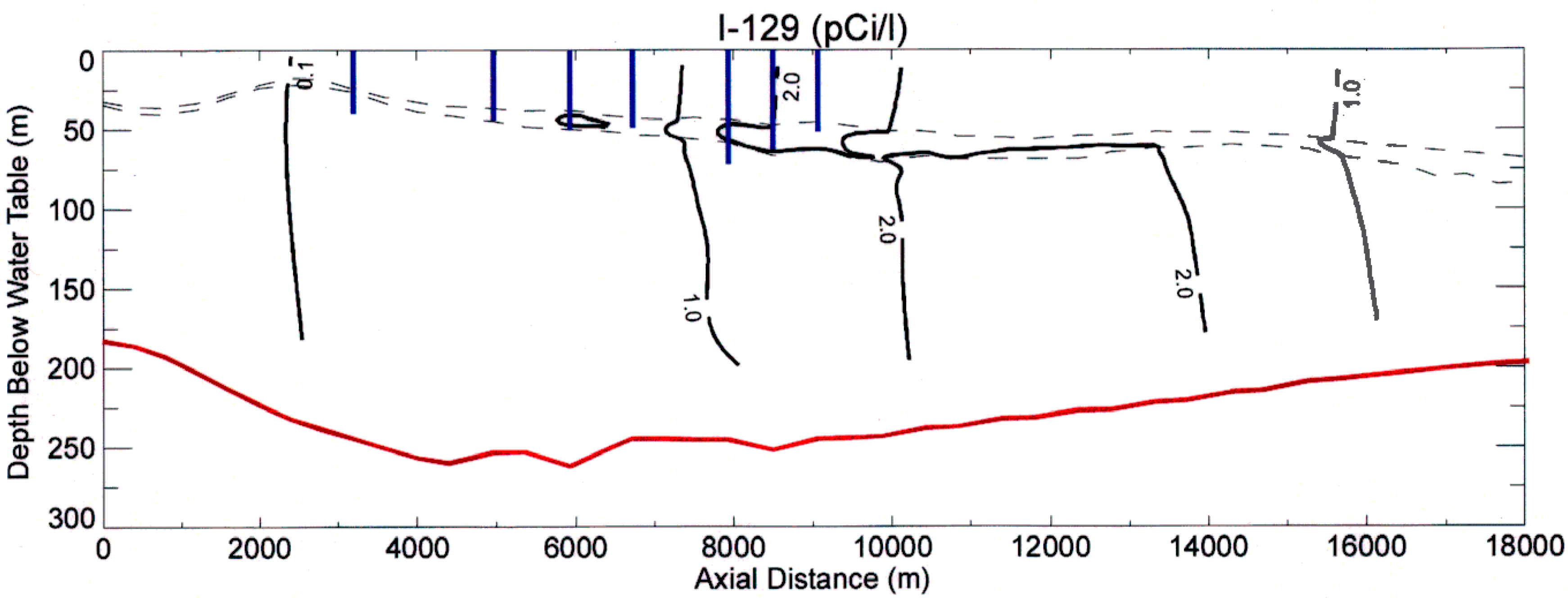


Figure 5-3. Simulated I-129 vertical concentrations in 2003 (the blue lines are well locations and red line is aquifer bottom).

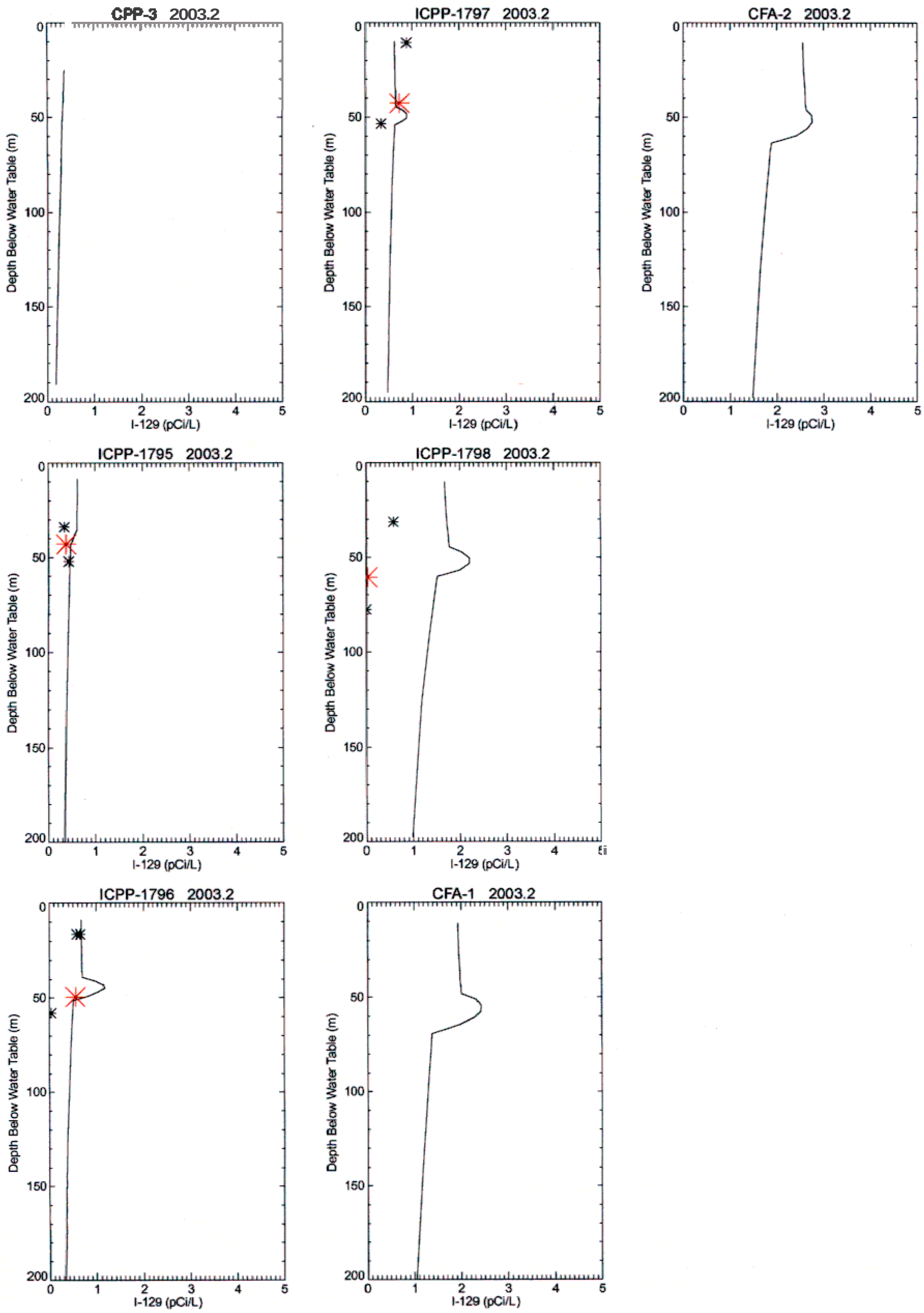


Figure 5-4. Simulated I-129 versus measured concentrations at vertical boreholes in 2003 (the solid line is simulated, the small asterisk is measured basalt, and the large asterisk is measured HI interbed).

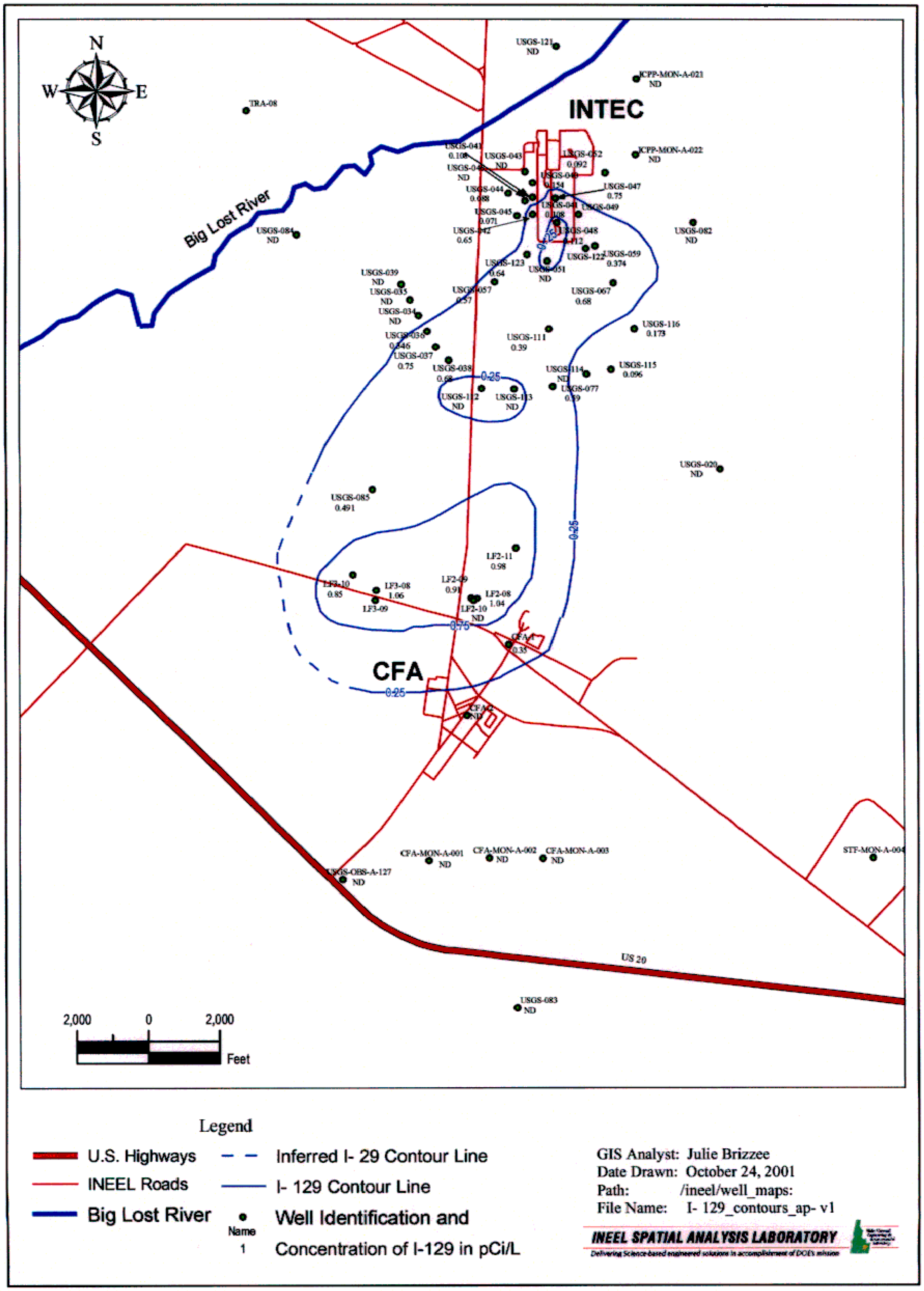


Figure 5-5. Observed I-129 aquifer concentrations in 2001.

## 5.39 Tritium

The operable Unit 3-13 RI/BRA tritium source consisted of 30,400 Ci of which 71% is from the INTEC area and 29% is from the Test Reactor Area (TRA). The 71% from the INTEC area is 66% injection well, 3% percolation ponds, and 2% other sources. The current model's vadose zone tritium flux was increased by a factor of 2.5 to match observed concentrations in the vertical profile boreholes. The increase represents 1,305 Ci out of 21,495 Ci total tritium released into the lithosphere from INTEC operations or 1,305 Ci out of 2,104 Ci total tritium released to the INTEC vadose zone. The increased vadose zone flux increase did not increase the total vadose zone tritium sources to the aquifer beyond 2,104 Ci during the 1954 through 2003 simulation period.

Simulated tritium concentrations exceeded the MCL through the year 1999. The simulated 2001 peak tritium concentration that was not associated with the TRA tritium plume was 13,905 pCi/L and was located 400 m south of the former percolation ponds. The peak tritium concentration measured during 2001 sampling was 14,000 pCi/L in Well USGS-114, which is located approximately 900 m south of the former percolation ponds. The tritium simulation was not performed beyond 2003 because of uncertainty in the vadose zone flux boundary condition, which needs to be better understood for predictive modeling. Figures 5-6 through 5-9 illustrate simulated tritium peak aquifer concentration, horizontal concentrations in 2001 at the water table, vertical concentrations in 2003, and simulated with observed in the vertical profile boreholes in 2003, respectively. The observed tritium concentrations from 2001 sampling are illustrated in Figure 5-10.

The simulated and observed tritium plumes are different, because the observed plume was estimated without using TRA tritium data and assuming the current plume is disconnected from the historical plume south of the CFA. Tritium concentrations south of the CFA in Wells USGS-104 and USGS-106 were approximately 1,000 pCi/L in 2003. These observations are still less than model predictions, but indicate that tritium originating from the INTEC is still observable south of the CFA.

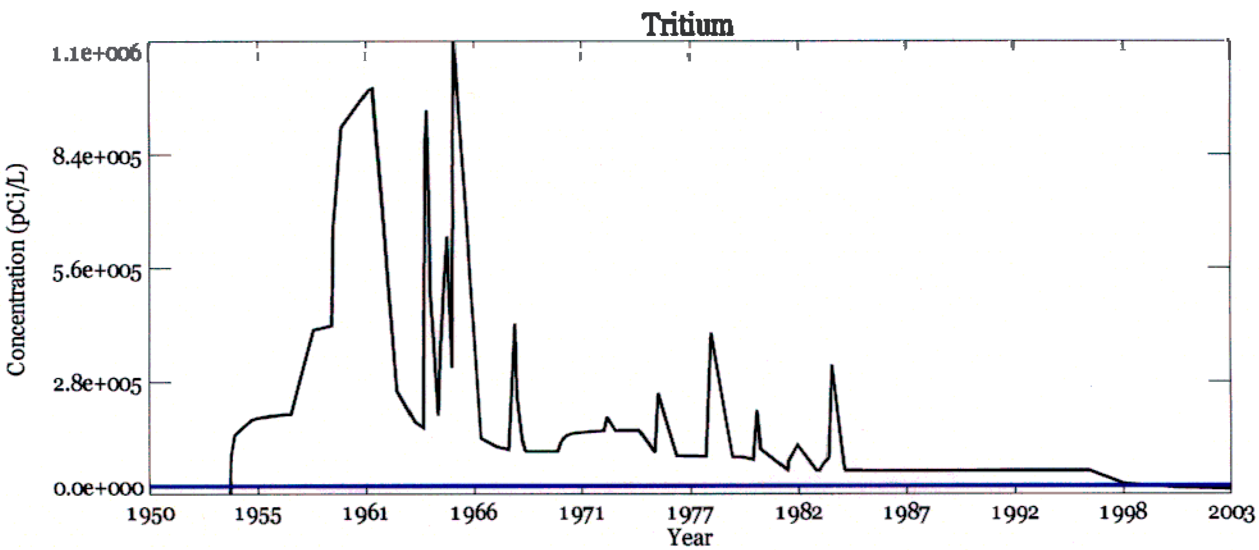


Figure 5-6. Simulated tritium (pCi/L) peak aquifer concentrations (blue line is the MCL).

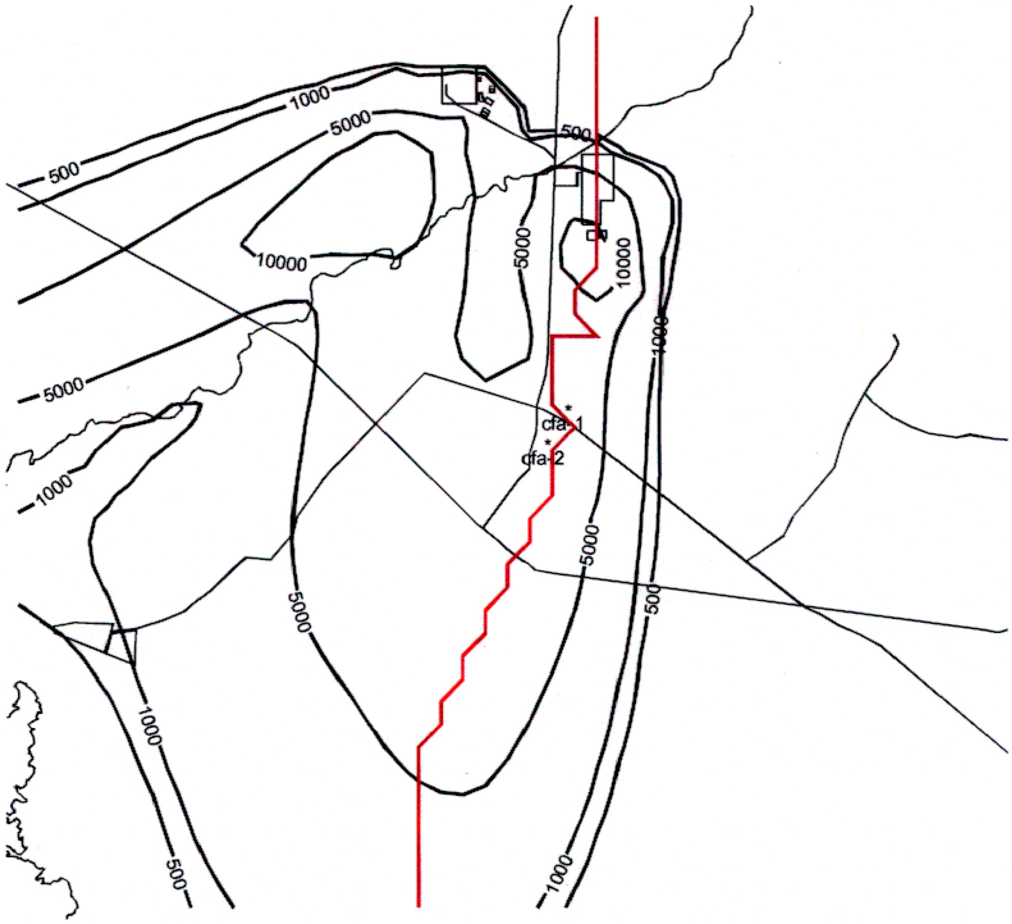


Figure 5-7. Simulated tritium (pCi/L) concentrations at the water table in 2001 (the thick red line is a fence diagram cross-section for Figure 5-8).

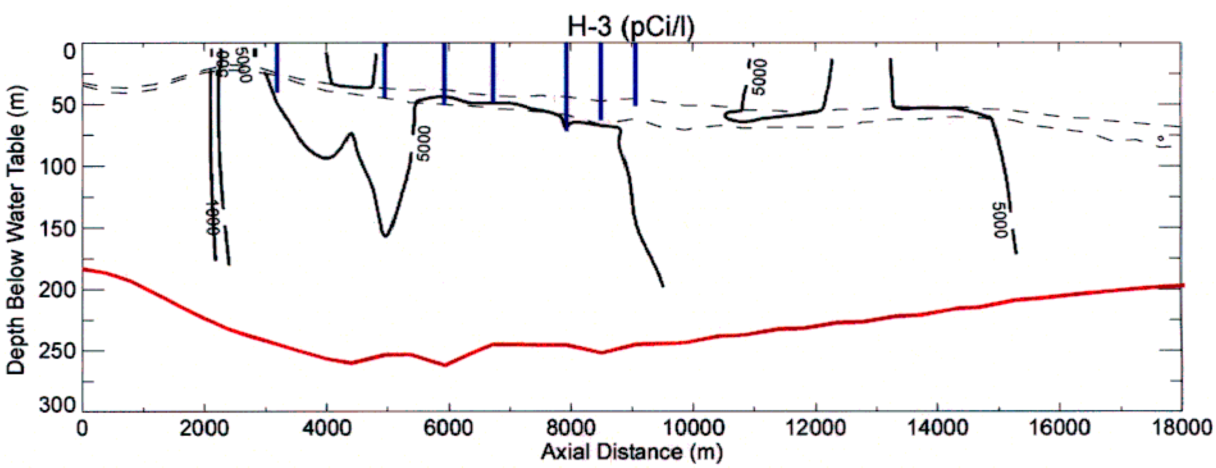


Figure 5-8. Simulated tritium vertical concentrations in 2003 (the blue lines are well locations and red line is aquifer bottom).

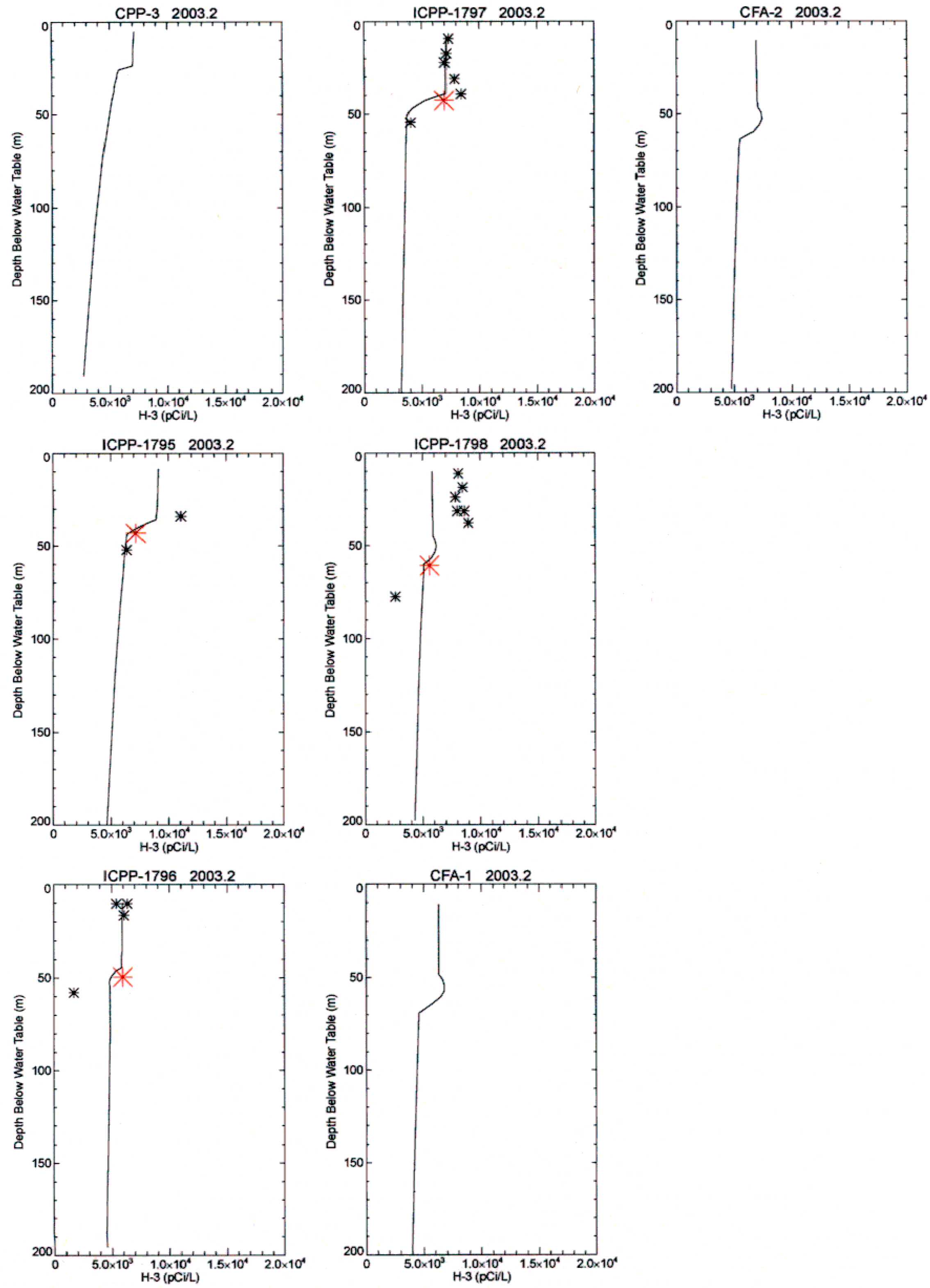


Figure 5-9. Simulated tritium versus measured concentrations at vertical boreholes in 2003 (the solid line is simulated, the small asterisk is measured basalt, and the large asterisk is measured HI interbed).

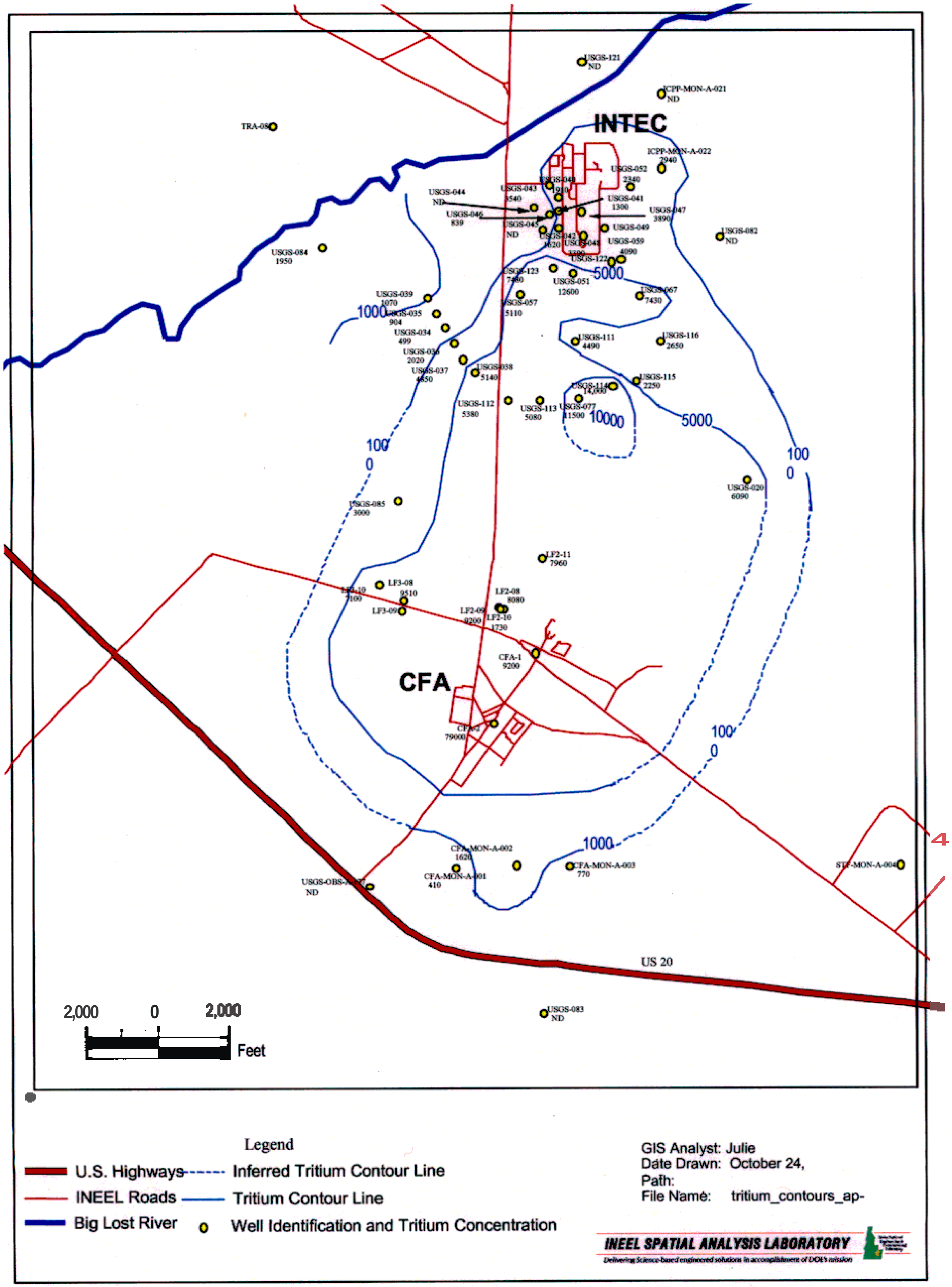


Figure 5-10. Observed tritium aquifer concentrations in 2001.

The tritium vertical sampling suggests the HI interbed may be acting as a confining layer between the deep and shallow aquifer, but concentrations are not as different as the earlier modeling indicated. Concentrations in the vertically sampled wells were higher than the model predicted without adjusting the vadose zone source term. This indicates there is a greater continuing tritium source from the aquifer than the OU 3-13 RI/BRA vadose zone model predicted. This increased vadose zone tritium flux may be due to the RI/BRA model underpredicting the rate tritium can migrate from the vadose zone or from additional and unknown tritium releases.

The current tritium contamination in the aquifer near INTEC is most likely from tritium discharged in the percolation ponds and tritium that entered the vadose zone during the injection well collapse. Approximately 16% of the total non-TRA tritium source was discharged to the percolation ponds and the injection well during the well collapse period. Tritium concentrations should decrease in the near hture as vadose zone sources are depleted and radioactive decay reduces the amount of tritium in the vadose zone. The decline in tritium aquifer concentrations should be faster than the 1-129 concentrations because of radioactive decay.

The model predicts tritium from the INTEC is widespread far south of the CFA. However, the current, very low contaminant concentrations in the USGS-83 well are not consistent with the current model. The current nondetect tritium concentration in this well is most likely an anomaly, because tritium sampling performed by WAG 4 in 2000 detected tritium in the USGS-104 well at 1,050 pCi/L and in the USGS-106 well at 1,110 pCi/L, which is more consistent with the model. Well USGS-104 is located approximately 3 km south of Highway 20 in a direction south of INTEC, and Well USGS-106 is located midway between the junction of Highway 20 and Lincoln Boulevard, and the Subsurface Disposal Area.

### 5.3.3 Technetium-99

The Operable Unit 3-13 RI/BRA Tc-99 source consisted of 2.69 Ci and is divided between 96% tank farm and 4% soil contamination. No records exist regarding the quantities of Tc-99 that might have been released into the injection well or percolation ponds; thus, these potential Tc-99 sources were not included during the RI/BRA modeling. The current model underpredicted concentrations in the vertical profile boreholes. Increasing the Tc-99 vadose zone flux improved the agreement with concentrations in the vertical profile boreholes, but increasing the vadose flux by the same 2.5 factor used in the tritium simulations overestimated the Tc-99 source by a factor 1.8 over the RI/BRA total source; therefore, this simulation was rejected.

The total Tc-99 source term was most likely underestimated in the RI/BRA modeling, because the injection well was assumed not to have received any Tc-99 during its operation. This assumption now appears to be incorrect. Historically, Tc-99 has been observed far south of the INTEC, suggesting Tc-99 was present in the service waste released into the injection well. The Tc-99 source term will need to be reevaluated with the planned update of the Group 4 vadose zone model.

Reducing the current model's aquifer basalt $K_d$ value from 0.006 to 0.0013 and the interbed $K_d$ value from 0.15 to 0.075 improved the agreement with the observations. The interbed $K_d$ was reduced by a factor of 2 from that used in the RI/BRA modeling and the aquifer basalt $K_d$ was 1/60 of the interbed value. This was needed to compensate for the larger retardation due a higher bulk density of the current model's lower basalt porosity (decreased from 6.25% of the Operable Unit 3-13 RI/BRA modeling to 3%). This is because retardation is directly proportional to the soil bulk density and bulk density is inversely proportional to porosity. Thus, the retardation will increase for a lower-porosity soil given the same $K_d$.

The contaminant interbed and basalt $K_d$ values are very uncertain model parameters. The SRPA basalt and HI interbed $K_d$ studies have not been performed and the Operable Unit 3-13 RI/BRA modeling values were estimated from studies performed on different geologic media from different sites. In lieu of performing site-specific $K_d$ studies, adjustment of modeling $K_d$ values was necessary to match observed conditions in the SRPA. The Operable Unit 3-13 RI/BRA modeling arbitrarily assumed basalt $K_d$ values to be 1/25 of that for sediment. This value most likely overestimated the fractured basalt $K_d$. This is because the majority of flow occurs in fractures and is not in contact with the entire media. In addition, the aquifer organic content is very low.

However, the uncertainty in vadose zone contaminant flux to the aquifer will most likely have a larger effect on simulated contaminant concentrations than the $K_d$ adjustment. The modeling $K_d$s values will need to be reevaluated when better understanding vadose zone transport and contaminant flux to the aquifer is gained during the Group 4 vadose zone model update.

In contrast to the tritium concentrations, the Tc-99 concentrations do not indicate concentrations are substantially different above, within, or below the interbed. Figures 5-11 through 5-14 illustrate simulated Tc-99 peak aquifer concentration, horizontal concentrations at the water table in 2001, vertical concentrations in 2003, and simulated with observed in the vertical profile boreholes in 2003, respectively. The observed Tc-99 concentrations from 2001 sampling are illustrated in Figure 5-15.

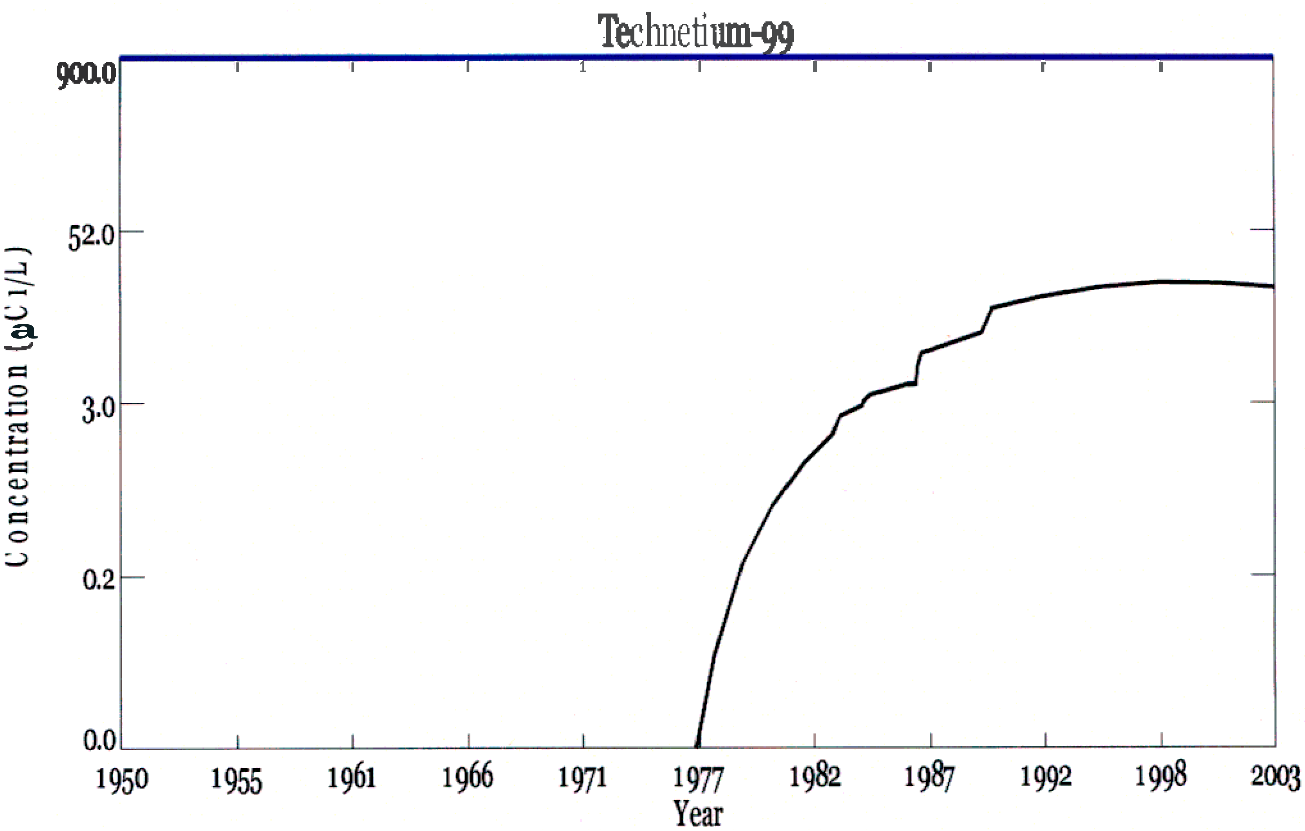


**Figure 5-11 Simulated Tc-99 peak aquifer concentrations (blue line is the MCL).**

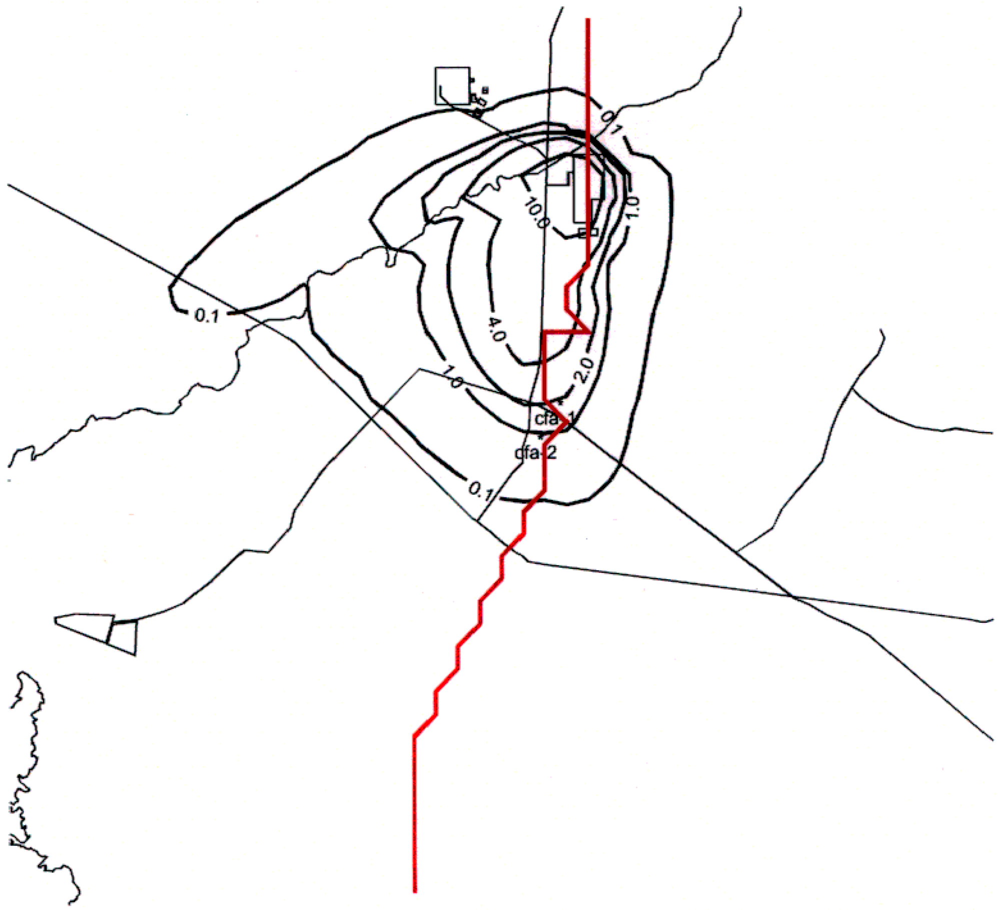


Figure 5-12. Simulated Tc-99 concentrations (pCi/L) at the water table in 2001 (the thick red line is a fence diagram cross-section for Figure 5-13).

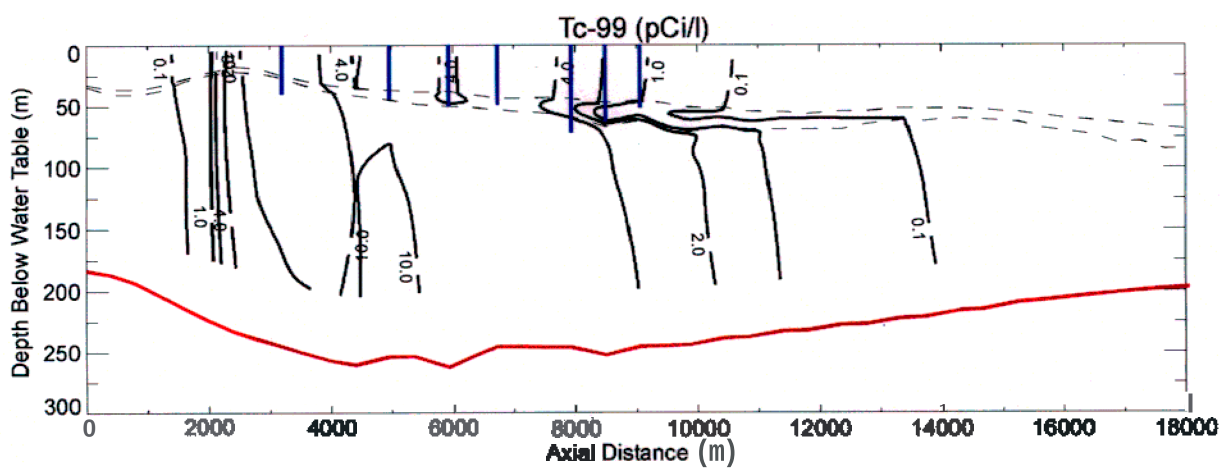


Figure 5-13. Simulated Tc-99 vertical ions in 2003 (the blue lines are well locations and red line is aquifer bottom).

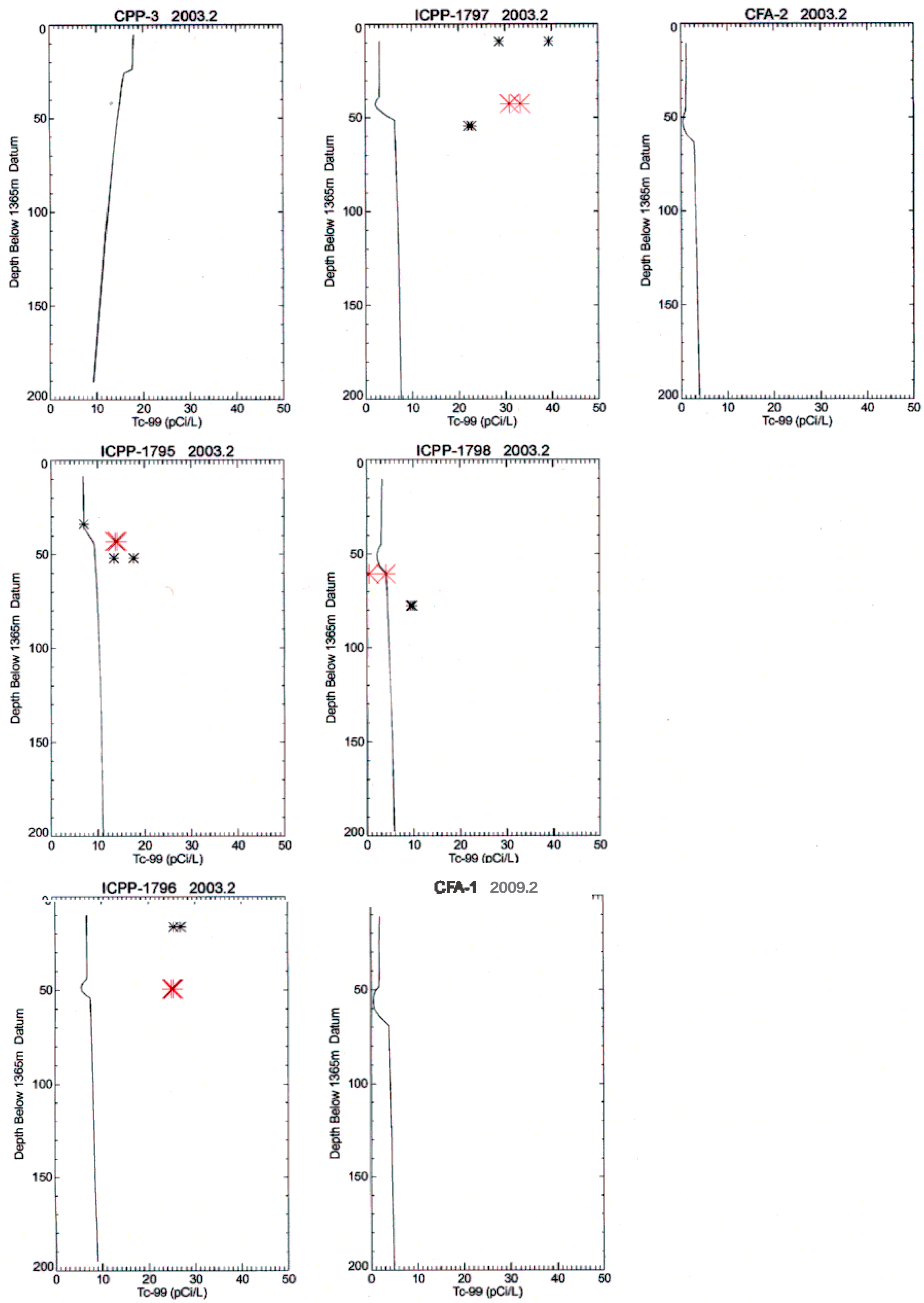


Figure 5-14. Simulated Tc-99 versus measured concentrations at vertical boreholes in 2003 (the solid line is simulated, the small asterisk is measured basalt, and the large asterisk is measured HI interbed).

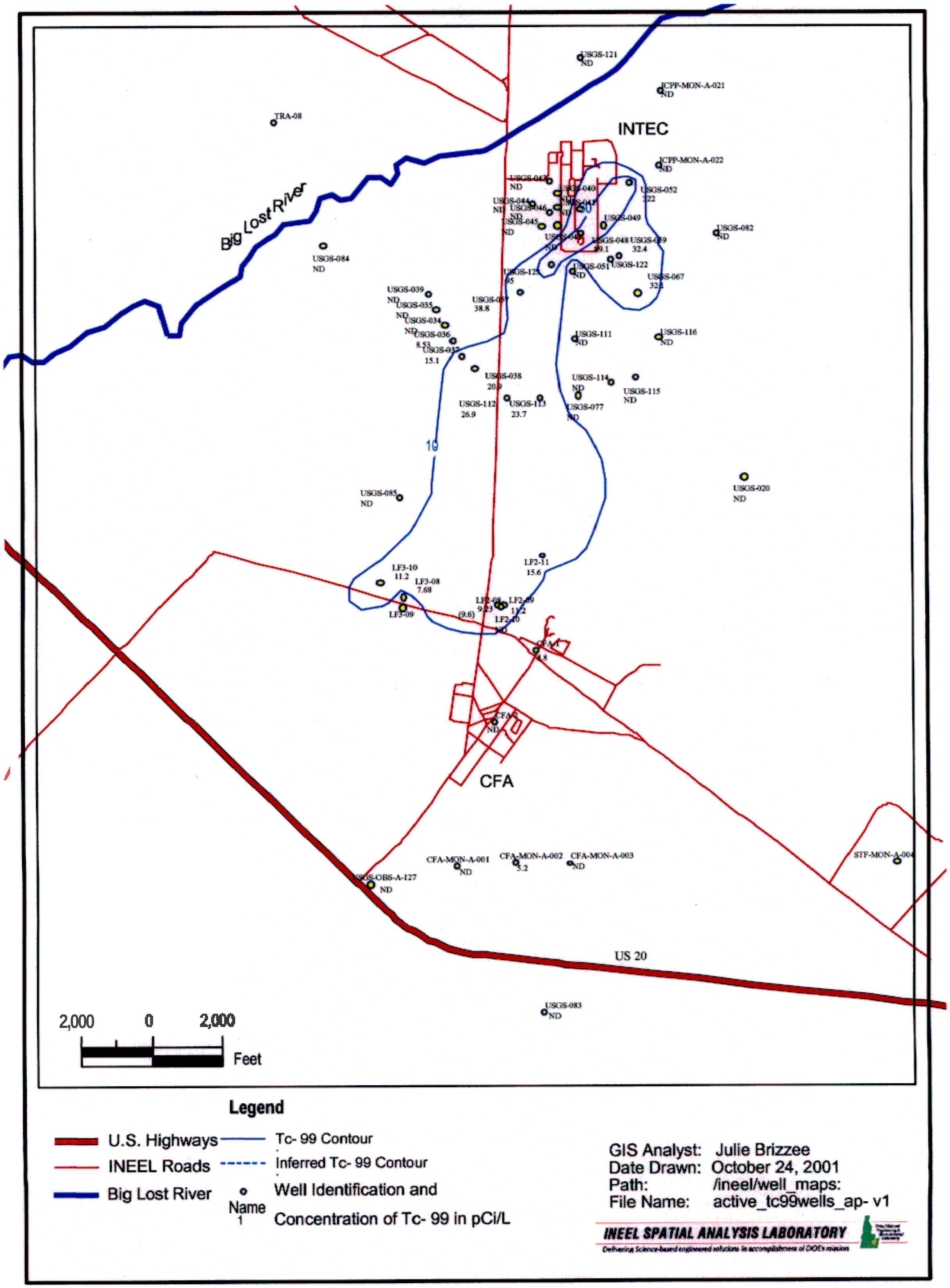


Figure 5-15. Observed Tc-99 aquifer concentrations in 2001.

Simulated Tc-99 concentrations were significantly underpredicted in the vertical profile boreholes. This may be due to the RI/BRA model overpredicting spreading in the vadose zone, thereby resulting in a vadose zone contamination footprint that is larger than that observed. The RI/BRA vadose zone model footprint extended approximately 700 m beyond the INTEC fence line in the east, west, and north directions and 1,100 m beyond the INTEC fence line in the south direction. The RI/BRA vadose zone model predicted contaminants would spread extensively in the horizontal direction, even west of the Big Lost River near TRA. This resulted in the current model overestimating the aquifer contamination in directions lateral and upgradient to the aquifer flow and underestimating peak aquifer concentrations directly beneath and downgradient of INTEC.

Simulated Tc-99 concentrations never exceeded the MCL throughout the 1954 through 2003 simulation period. The Tc-99 simulation was not performed beyond 2003 because of uncertainty in the vadose zone flux boundary condition, which needs to be better understood for predictive modeling. The simulated 2001 peak Tc-99 concentration was 21.5 pCi/L and was located near the northwest corner of INTEC. The observed peak Tc-99 concentration measured during 2003 was 2,840 ± 43.4 pCi/L in new SWA Monitoring Well ICPP-MON-A-230. This well is located inside the INTEC, approximately 300 ft north of the tank farm's northern fence line. Because Tc-99 was detected in the aquifer at concentrations much higher than observed previously, a special investigation of the occurrence of Tc-99 at INTEC was initiated in August 2003. The final results of the Tc-99 investigation are not yet available, but will be reported in the 2004 Annual Well Monitoring Report. Preliminary results suggest that the Tc-99 appears to have been present in the SWA beneath the northern portion of INTEC for many years. The most likely source of the Tc-99 in the groundwater in this area appears to be from past releases that occurred at the tank farm. The most likely mechanism for transport of Tc-99 to the aquifer is downward movement of contaminated water through the vadose zone to the water table. The former INTEC injection well likely constituted an earlier source of Tc-99 to the aquifer, but groundwater Tc-99 concentrations in the aquifer associated with the former injection well were far below the MCL. The INTEC vadose zone model will be revised in 2004 to better predict the migration of Tc-99 through the vadose zone to the aquifer.

### 5.3.4 Strontium-90

The Operable Unit 3-13 RI/BRA Sr-90 source consisted of 19,400 Ci and is divided between 92% tank farm, 6% soil contamination, and 2% other sources (including only 0.12% from the INTEC injection well). Increasing the Sr-90 vadose flux by a factor of 2.5 had no significant change in aquifer concentrations, because very little Sr-90 is predicted to enter the aquifer from the RI/BRA vadose zone model throughout the 1954 through 2003 simulation period. This is because Sr-90 is more strongly retarded in the vadose zone by adsorption than the other contaminants.

As with the Tc-99 simulations, better agreement with the observed Sr-90 concentrations was obtained by reducing the interbed $K_d$ value from 12 to 6 and setting the aquifer basalt $K_d$ to be 1/60 of the interbed value. This was needed to compensate for the larger retardation due to a higher bulk density of the current model's lower basalt porosity (decreased from 6.25% of the Operable Unit 3-13 RI/BRA modeling to 3%). This is because retardation is directly proportional to the soil bulk density and bulk density is inversely proportional to porosity. Thus, the retardation will increase for a lower-porosity soil given the same $K_d$. The $K_d$ reduction factor is the same as that used to improve the Tc-99 simulation's agreement with the observed data. As with the Tc-99 concentrations, the observed Sr-90 concentrations do not indicate that concentrations are substantially different above, within, or below the interbed.

The simulated Sr-90 concentrations exceeded the MCL throughout the 1954 through 2003 simulation period. The simulated 2001 peak Sr-90 concentration was 19.1 pCi/L and was located 400 m southwest of the former percolation ponds. The peak Sr-90 concentration measured during 2001 sampling was 26.4 pCi/L in Well USGS-123, which is located approximately 300 m northwest of the former percolation ponds. The Sr-90 simulation was not performed beyond 2003 because of uncertainty in the vadose zone flux boundary condition, which needs to be better understood for predictive modeling.

Figures 5-16 through 5-19 illustrate simulated Sr-90 peak aquifer concentration, horizontal concentrations at the water table in 2001, vertical concentrations in 2003, and simulated plus observed concentrations in the vertical profile boreholes in 2003, respectively. The observed Sr-90 concentrations from 2001 sampling are illustrated in Figure 5-20.

The current Sr-90 contamination in the aquifer near INTEC is most likely derived primarily from the injection well even though it only accounts for 0.12% of the total Sr-90 source from INTEC. The bulk of the tank farm and soil contamination Sr-90 has not yet reached the aquifer because of retardation in the vadose zone. The injection well Sr-90 will remain near the INTEC longer than the other simulated contaminants because of retardation in the aquifer. Aquifer concentrations should decrease in the near future, but could begin to increase if surface recharge cannot be reduced during the OU 3-13 Group 4 remedial actions. As with the Tc-99 simulations, the current model Sr-90 from the vadose zone appears to be spread over a larger area than the 2001 groundwater sampling indicates.

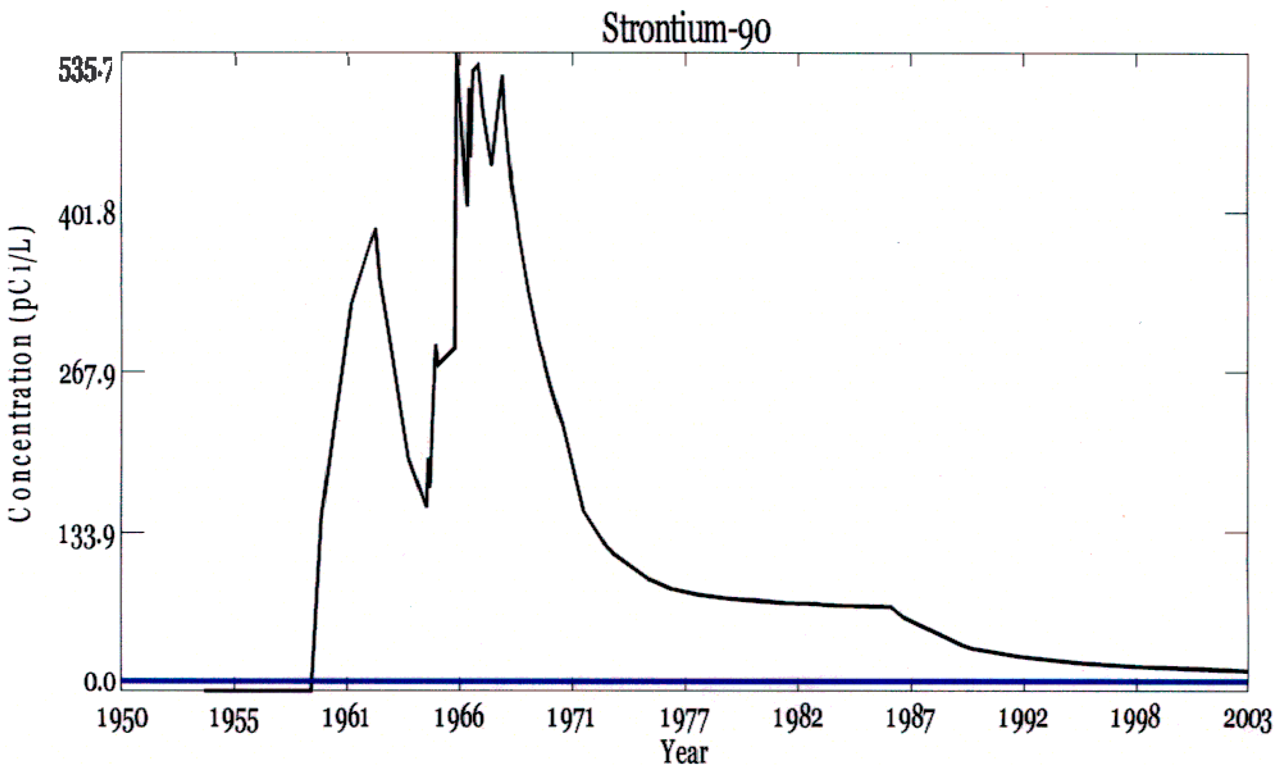


Figure 5-16. Simulated Sr-90 peak aquifer concentrations (blue line is the MCL).

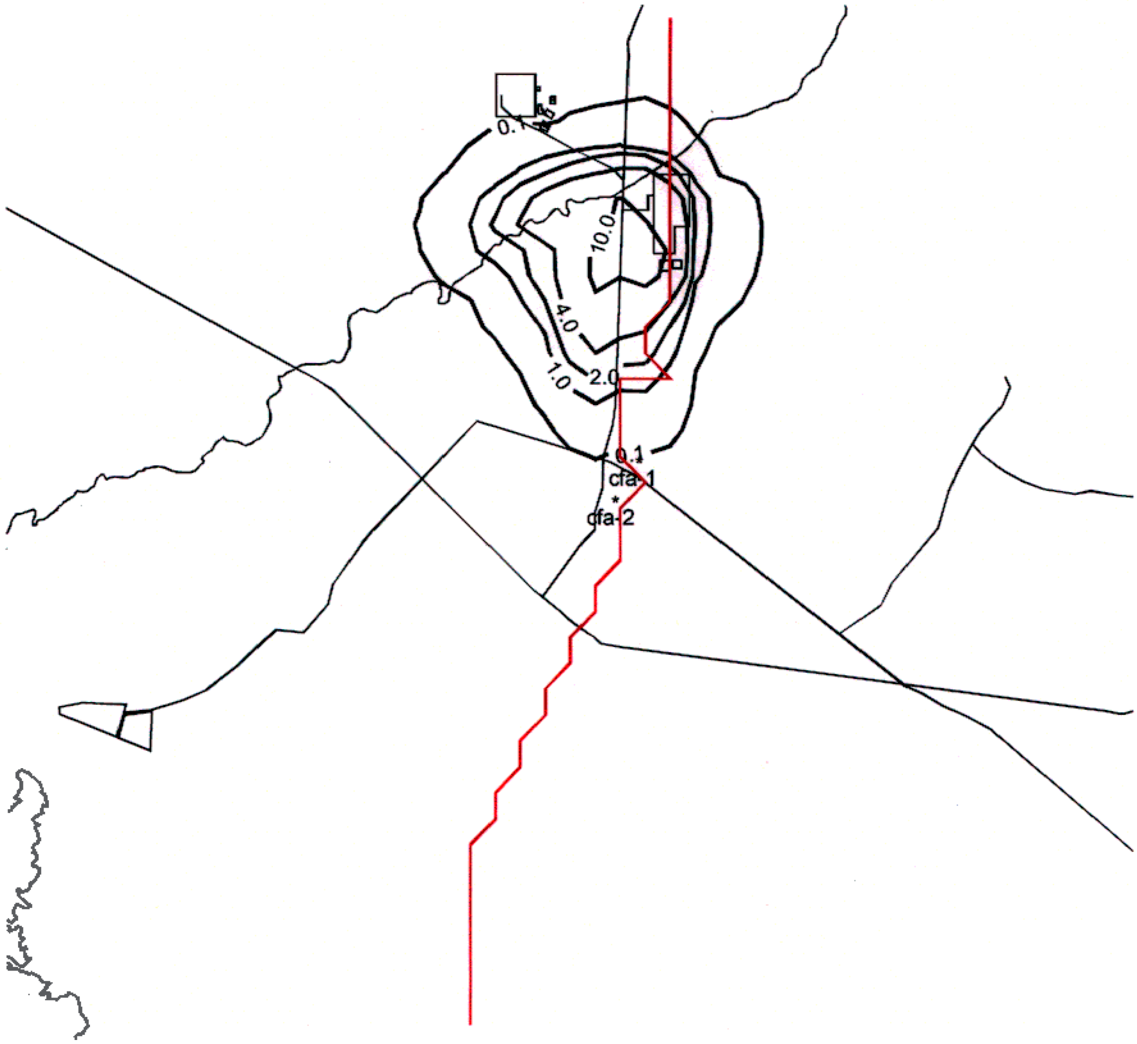


Figure 5-17. Simulated Sr-90 concentrations (pCi/L) at the water table in 2001 (the thick red line is a fence diagram cross-section for Figure 5-18).

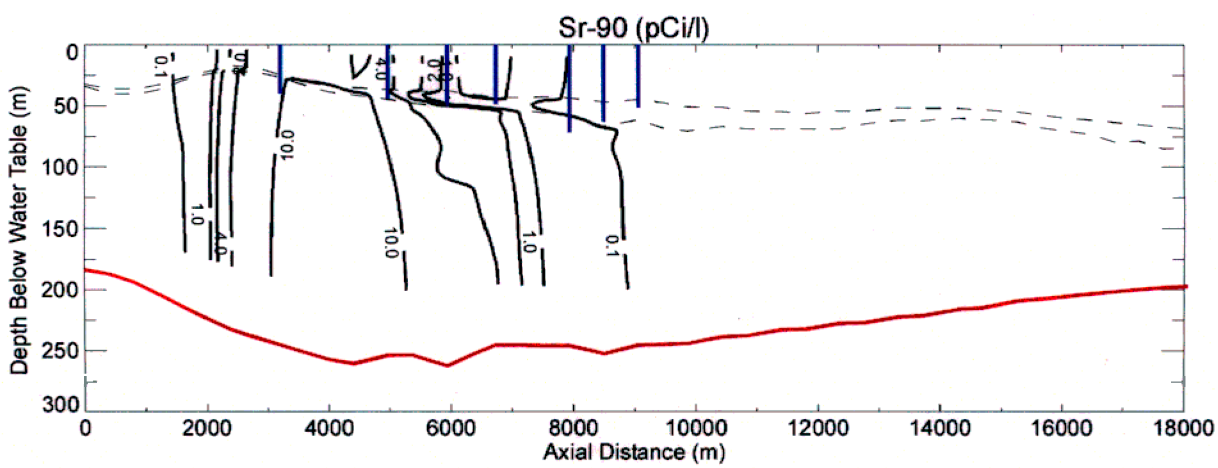


Figure 5-18. Simulated Sr-90 vertical concentrations in 2003 (the blue lines are well locations and red line is aquifer bottom).

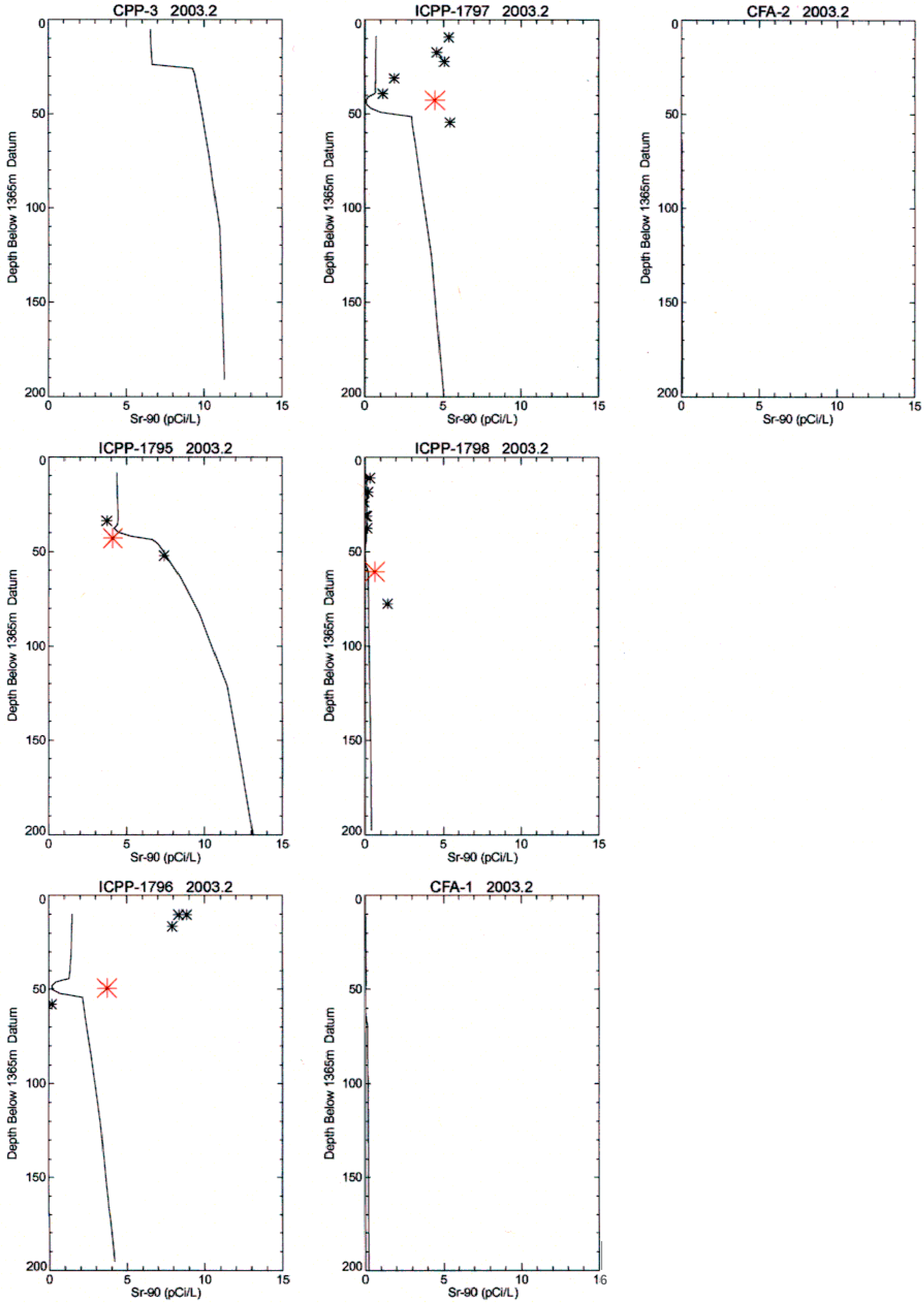


Figure 5-19. Simulated Sr-90 versus measured concentrations at vertical boreholes in 2003 (the solid line is simulated, the small asterisk is measured basalt, and the large asterisk is measured HI interbed).

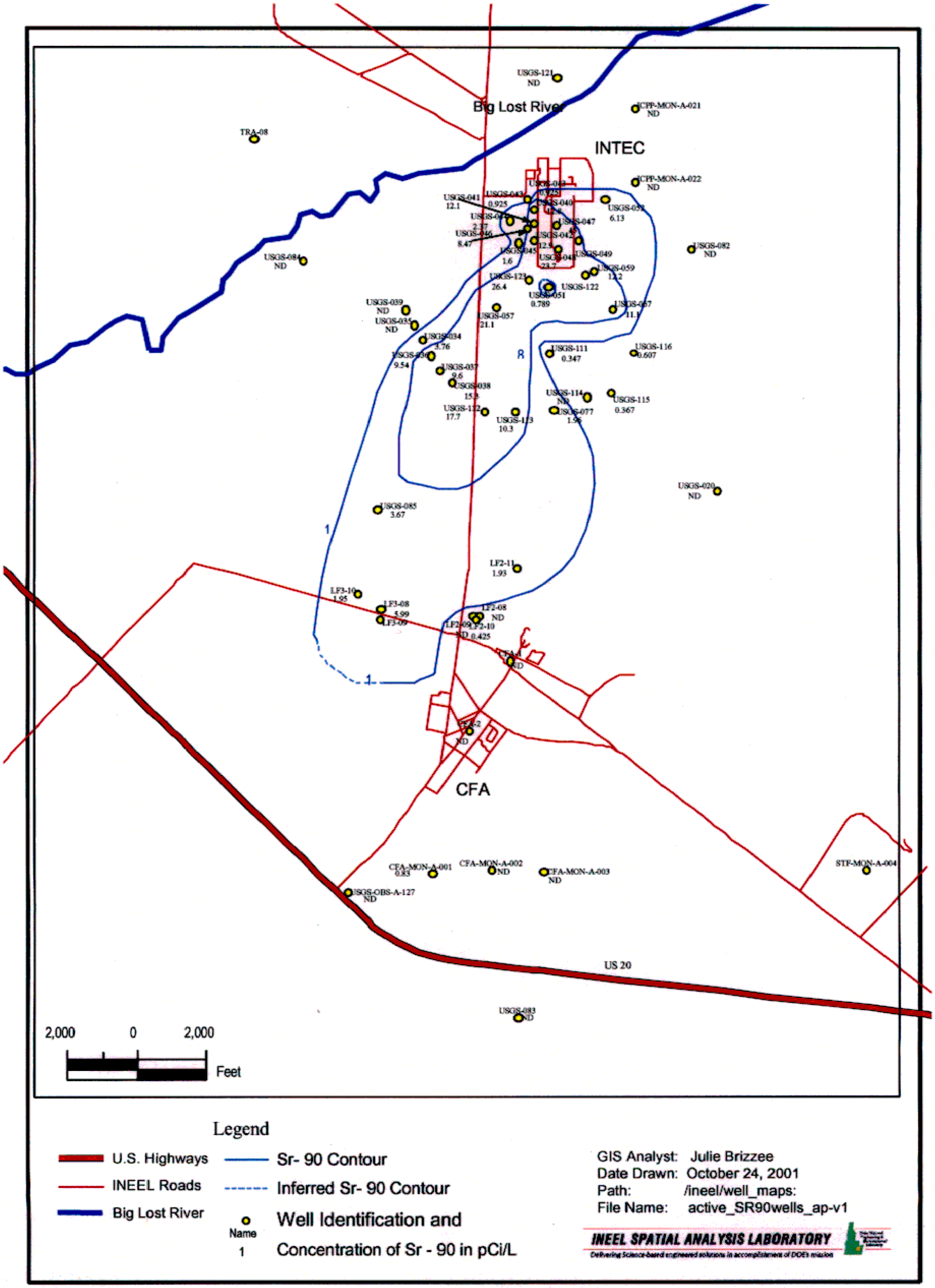


Figure 5-20. Observed Sr-90 aquifer concentrations in 2001.

# 6. GROUNDWATER MONITORING RESULTS AND TRENDS

Existing groundwater quality data downgradient of INTEC were reviewed to assess whether the OU 3-13, Group 5 RAO #2 will be met (MCLs met by 2095). Appendix C includes concentration trend plots for tritium, Sr-90, and 1-129 concentrations reported in USGS monitor wells located near and downgradient of INTEC.

In summary, groundwater-monitoring results collected through 2003 demonstrate the following:

- Tritium activities have declined below the drinking water MCL (20,000 pCi/L) in all **SWA** monitoring wells at and downgradient of INTEC.
- Iodine-129 activities have declined below the MCL (1 pCi/L) in all SWA monitoring wells at and downgradient of INTEC.
- Iodine-129 concentrations in depth-specific groundwater samples collected by the Idaho National Engineering Laboratory Oversight Programs during 1992–1994 were less than the I-129 MCL of 1 pCi/L (McCurry and Welhan 1996).
- Strontium-90 activities in several SWA monitoring wells downgradient of the former injection well remain significantly above the drinking water MCL of 8 pCi/L.

Groundwater monitoring results show that tritium and 1-129 activities are already below their respective MCLs in all SWA monitoring wells downgradient of INTEC. Figure 6-1 shows the 1-129 groundwater plume downgradient of INTEC as it existed during 1986, 1990–1991, 2001, and 2003. The I-129 groundwater plume has diminished considerably in both areal extent and in peak concentration over this time period. Coupled with the modeling results, the observed dissipation of the 1-129 plume over the past 2 decades provides strong evidence that the RAOs will be met before 2095.

The Sr-90 activities in the aquifer currently exceed the MCL downgradient of INTEC, but Sr-90 concentrations are slowly declining in all wells (Appendix C), and groundwater quality trends indicate that Sr-90 activities in groundwater outside the INTEC security fence will decline below the MCL by 2095. However, some perched monitoring wells close to the tank farm contain very high Sr-90 activities (e.g., 147,000 pCi/L Sr-90 in MW-2 in 2003). Therefore, it is apparent that vadose zone and aquifer matrix materials near the tank farm constitute a residual secondary source of Sr-90 that could potentially reach groundwater at some hture time. Contaminated soil and perched water beneath the tank farm and surrounding area are being investigated and addressed under OU 3-14, and the infiltration of water through contaminated soil is being reduced in accordance with the Group 4 remedy *(Institutional Controls with Aquifer Recharge Control).*

Additional details regarding groundwater quality results and trends beneath and south of INTEC can be found in Appendix D, the *Annual INTEC Groundwater Monitoring Report for Group 5—Snake River Plain Aquifer (2001)* (DOE-ID 2002c), and the *Annual INTEC Groundwater Monitoring Report for Group 5—Snake River Plain Aqulfer (2003)*, (DOE-ID 2003c).

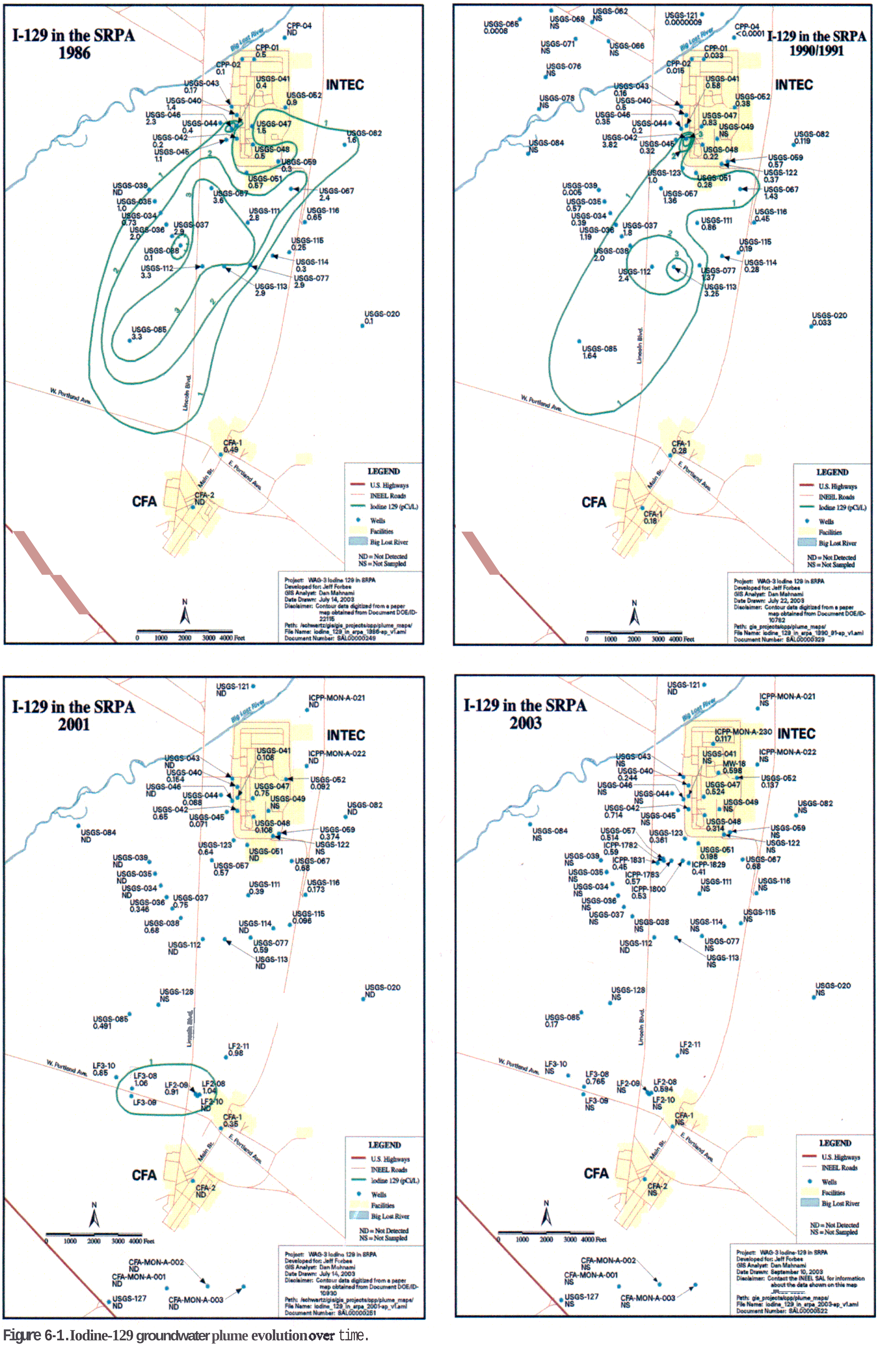


Figure 6-1. Iodine-129 groundwater plume evolution over time.

# 7. CERTIFICATION THAT REMEDY IS OPERATIONAL AND FUNCTIONAL

The remedy for Group 5 specified in the OU 3-13 ROD *(Institutional Controls with Monitoring and Contingent Remediation)* is operational and functional (DOE-ID 1999). Institutional controls are currently in place and groundwater monitoring is being performed to ensure that the RAOs for the aquifer are met. The RAOs are (1) “Prior to 2095, prevent current on-site workers and general public from ingesting SWA groundwater that exceeds a cumulative carcinogenic risk of $1 \times 10^{-4}$, a total HI [hazard index] of 1, or applicable State of Idaho groundwater quality standards (i.e., MCLs)” and (2) “In 2095 and beyond, ensure that SWA groundwater does not exceed a cumulative carcinogenic risk of $1 \times 10^{-4}$, a total HI [hazard index] of 1, or applicable State of Idaho groundwater quality standards.” The first RAO is being met by maintaining institutional control over the area of the identified SWA contaminant plume south of the current INTEC security fence for as long as contaminant levels remain above groundwater standards or risk-based groundwater concentrations. The general actions required to meet the second RAO (post-2095) were spelled out in the OU 3-13 ROD (DOE-ID 1999).

The revised flowchart for the Group 5 remedy is shown in Figure 7-1. The flowchart shows the decision logic and key decision points reached during this plume evaluation field investigation. As shown in the flowchart, there has been no need to invoke the contingent remedy (groundwater pump and treat), and the results of groundwater sampling across the HI interbed have precluded the need for additional investigations (e.g., pumping tests, treatability studies). Based on the DQOs established for the Group 5 remedy, the flowchart shows the path forward to be periodic plume monitoring.

Both groundwater monitoring results (Section 3) and the revised groundwater flow model (Appendix B) demonstrate that the 1-129 hot spot above the MCL that had previously been predicted downgradient of INTEC does not exist. Concentrations of all radionuclides of concern are declining in the aquifer (Appendix C). Therefore, assuming that the Group 4 remedy is successful in reducing infiltration through the vadose zone, there is no reason to believe that the Group 5 remedy will not be successful in achieving the RAOs established for the aquifer by the year 2095. In any case, 5-year reviews will continue to be conducted as required under CERCLA (42 USC § 9601 et seq.) to assess the effectiveness of the selected remedial alternative, to assess the need for its continuation, or to consider a different alternative, should additional information come to light suggesting that RAOs may not be achieved. The 5-year review report for OU 3-13 Group 5 will be submitted in October 2005.

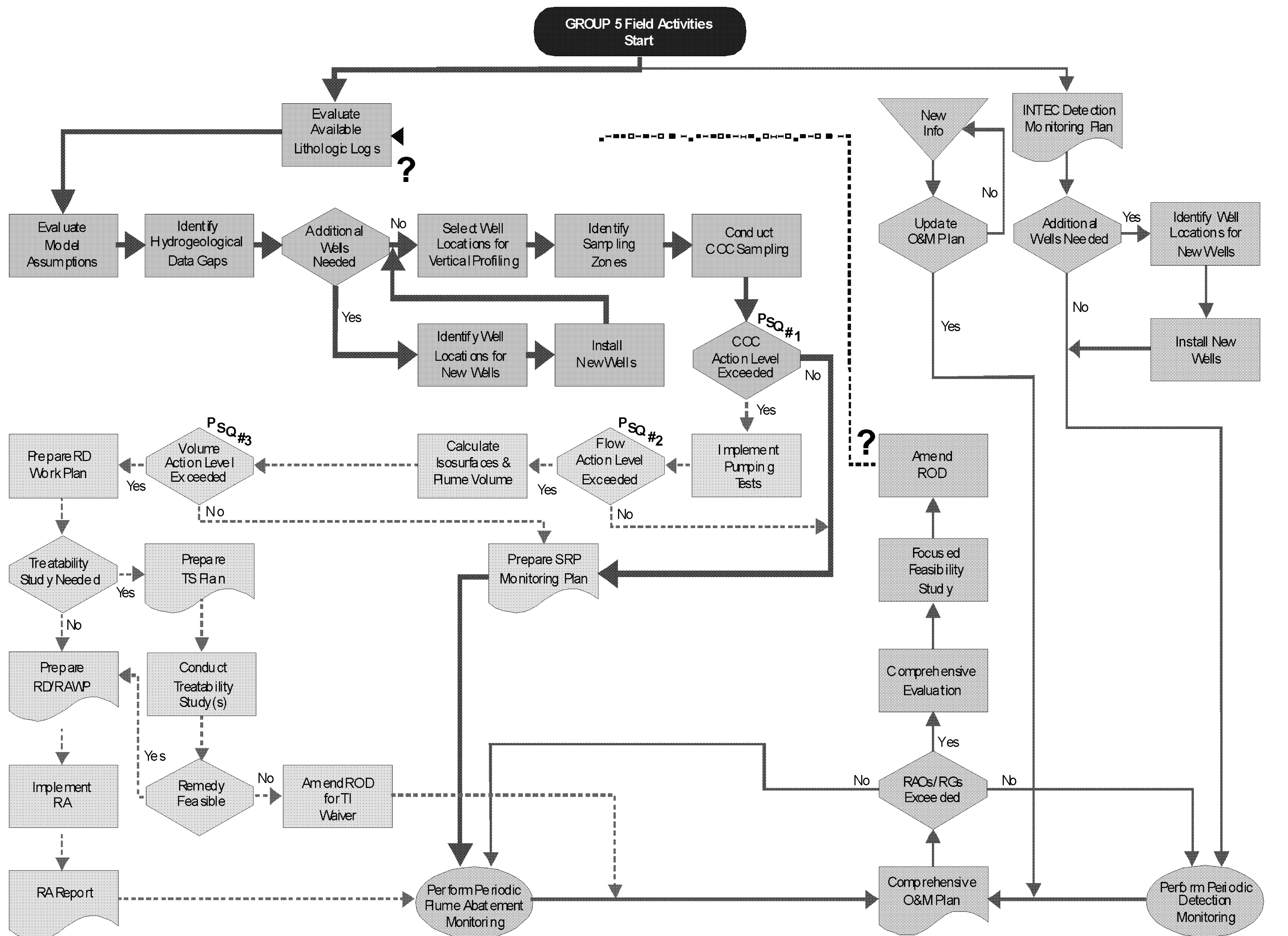


Figure 7-1 Flow chart showing decision logic for Group 5 remedy.

# 8. OPERATIONS AND MAINTENANCE PLAN

Remedial action reports typically include an operations and maintenance plan. With regard to the Group 5 remedy *(Institutional Controls with Monitoring and Contingent Remediation),* the operations and maintenance plan consists of a groundwater-monitoring schedule. This schedule is detailed in the *Monitoring System and Installation Plan for Operable Unit 3-13, Group 5, Snake River Plain Aqulfer* (DOE-ID 2002b), and the *Long-Term Monitoring Plan for Operable Unit 3-13, Group 5 Snake River Plain Aquifer* (DOE-ID 2003d). The Long-Term Monitoring Plan contains a list of wells to be sampled, constituents for which those samples will be analyzed, and details of the sample collection procedures. The Long-Term Monitoring Plan will be revised during FY 2004 to reflect proposed revisions to sampling frequencies and suites of analytes for individual SRPA monitoring wells.

# 9. PROJECT COSTS

Table 9-1 summarizes actual costs for OU 3-13 Group 5 remedial activities for the period between FY 2000 and FY 2003. Project surveillance and monitoring costs also are shown for the 92-year period remaining until the 2095 date specified in the ROD. Table 9-2 shows the costs estimated in the OU 3-13 ROD for the 100-year period assumed for the Group 5 interim remedial action.

Table 9-1. Actual project costs for Group 5 remedial action (2000 through 2003).

| Fiscal Year | Actual Costs ($) |
|---|---|
| 2000 | $497,345 |
| 2001 | $408,721 |
| 2002 | $998,985 |
| 2003 | $960,368 |
| Total actual project costs (2000–2003) | $2,865,419 |
| Projected hture Group 5 costs* (2004–2095) | $15,558,120 |
| Estimated total Group 5 costs (2000–2095) | $18,423,539 |

* Based on the 100-year surveillance and monitoring cost from the Operable Unit 3-13 Record of Decision multiplied by 0.92 to allow for 92 years of monitoring remaining until 2095; does not include costs for contingent remedy.

Table 9-2. Operable Unit 3-13 Record of Decision estimated costs for Snake River Plain Aquifer interim action (100 years).

| | |
|---|---|
| Capital costs | |
| FFA/CO Management and Oversight | $5,300,000 |
| Remedial design | $4,302,000 |
| Remedial action construction | $14,855,000 |
| Total capital cost in FY-97 dollars | $24,457,000 |
| Operation costs | |
| Remedial action operations | $16,141,000 |
| Decontamination and decommissioning of facilities | $1,647,000 |
| Surveillance and monitoring | $16,911,000 |
| Total operation cost in FY-97 dollars | $34,699,000 |
| Total project cost in FY-97 dollars | $59,156,000 |

FFA/CO = Federal Facility Agreement and Consent Order
FY = fiscal vear

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